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Influence of solute transport and capillarity on bubble evolution in porous networks

Tuesday, 31 May 2022 16:30 (15 minutes)

Understanding the temporal and spatial evolution of bubbles in porous media is key to applications such as gas storage in subsurface rocks, air-entrained concrete, and contaminants transport in soil.
In the simplest case of a spherical bubble in unconfined bulk liquid, the evolution of the bubble can be predicted by considering its capillary pressure and the solute concentration in the liquid layer adjacent to the bubble/liquid interface. The presence of a porous medium complicates the growth and dissolution process, by introducing two controlling factors. First, as a bubble grows beyond the size of a pore body, its capillary pressure depends not only on its volume, but also on the local network geometry [1,2]. Second, the pore network limits transport fluxes from/to the bubble and leads to local concentration development, yielding a non-uniform solute concentration field [3]. The experimental evidence of the evolution of bubble lattices in porous media have been so-far quite limited.

Here, we investigate the mechanisms controlling the evolution of a bubble lattice in a porous network by comparing simulation results from a pore-network model [3] to microfluidic experiments. The pore-network simulation couples solute transport and bubble dissolution processes and outputs the temporal evolution of bubble radius and solute concentration on a pore-by-pore level. The experiments were performed with CO_2 and water at isothermal, ambient conditions within three distinct two-dimensional glass micromodels that feature a regular pore-network differing solely in the throat diameter. An image processing routine was developed to extract the temporal evolution of size and local curvatures of each bubble. We observed distinct modes of bubble growth and dissolution. The relative differences between the capillary pressure of a bubble and the value of its immediate neighbours were computed at each time. We analysed the relationship between the rate of change of the bubble volume and this "relative"capillary pressure to identify both linear and non-linear regimes. The absence of a linear regime during bubble dissolution (or growth) provides direct evidence that the process is not solely controlled by capillarity, but also by transport and accumulation of solute in pores.

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References

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Time Block Preference

Time Block B (14:00-17:00 CET)

Participation

Unsure

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